# Cut-and-Paste Editing of Multiresolution Surfaces

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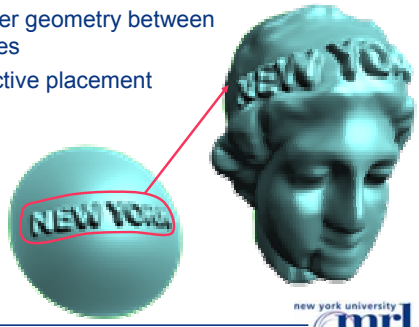
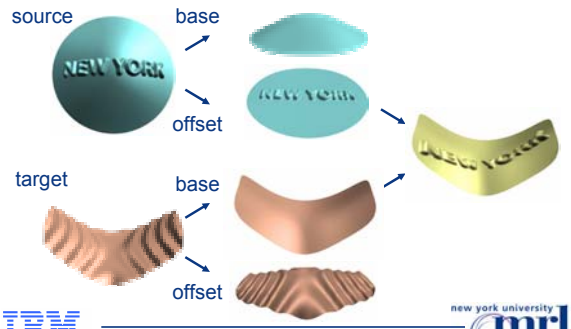
## Surface Pasting

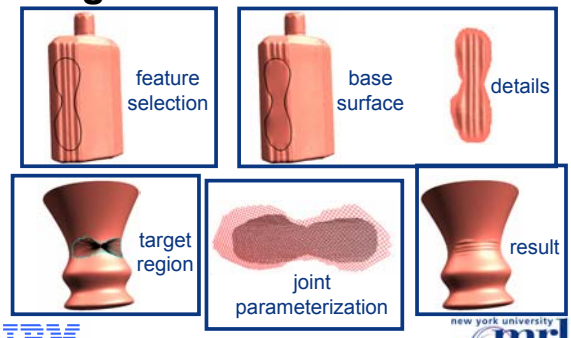
- Transfer geometry between surfaces
- Interactive placement



## Approach




## Algorithm Overview




## Related Work

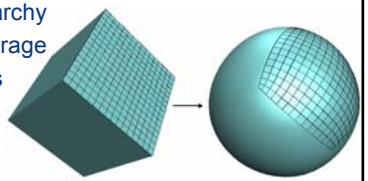
Spline pasting
- Forsey [88], Barghiel [95], Mann [97]

Base/detail separation
- Kobbelt [98], Guskov [99], Lee [00]

Surface parameterization
- Eck [95], Pedersen [95,96], Floater [97], Guskov [00], Sheffer [00], Desbrun [02], Levy [02]

## Multiresolution Surfaces

Efficient algorithms and data structures
- Natural parameterization
- Natural hierarchy
- Compact storage
- Local frames



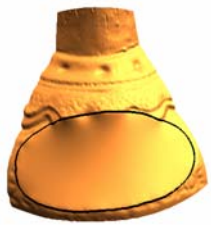
## Base / Detail Separation

- Controlled by a single parameter: flatness
- Smoothly varying from soapfilm to the original surface
- Use soapfilm surface to get a flatter base than the coarsest level
- Use fitting/quasi-interpolation at different subdivision levels to get discrete set

## Family of Base Surfaces

source

target



base surface

pasting result

## Target Region Finding

### Problem

- Find the target region to be parameterized
- Closely match feature size and shape

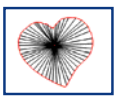
### Approach

- Parameterize source boundary w.r.t. a spine
- Transfer the spine to the target surface
- Identify boundary on target, perform flood fill

## Radial Parameterization

- Source: parameterize feature boundary by angle and distance
- Target: shoot geodesic rays, connect their endpoints

selected region



radial parameterization

target region

## Geodesics

### Continuity property:

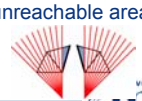
> "The distance between the endpoints of two geodesics emanating from the same point can be made arbitrarily small by decreasing the angle between them."

- Not true for straightest geodesics!
- Saddle problem:

flattened saddle

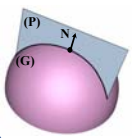
straight paths

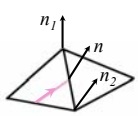
unreachable areas

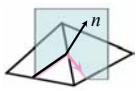


## Normal Geodesics

- Geodesics on smooth surfaces are locally normal curves
- Discrete setting: walk from triangle to triangle in a direction perpendicular to the normal interpolated from the vertex normals

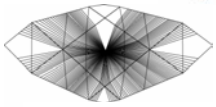


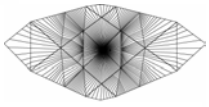



# Geodesics

3D saddle mesh



straightest geodesics



interpolated normal geodesics

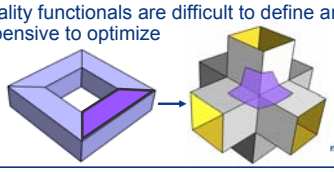


# Parameterization

Approach: parameterize both source and target onto a plane

Why use an intermediate plane?

- Direct construction of mapping from surface to surface is difficult
- Quality functionals are difficult to define and expensive to optimize





# Requirements

- One-to-one for resampling purposes
- Minimize distortion
- Free boundary

selected feature

parameterization

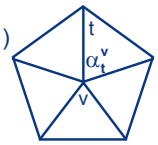
- Until recently, nothing available; now several options: Sheffer '00, Desbrun '02, Levy'02

# Angle-Based Flattening

(Sheffer & de Sturler'00)

Use angles as variables:

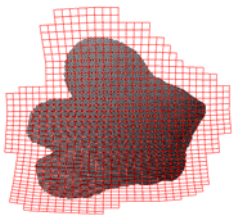
- Set target angles $\varphi_t^v$ so that at each vertex v angles sum up to $2\pi$ (scale angles by $2\pi / \sum_t \alpha_t^v$ )
- Optimize $\sum_{t,v} w_t^v \left(\alpha_t^v - \varphi_t^v\right)^2$ subject to constraints






# Nonlinear Optimization

- The flatter the mesh, the faster it converges
- Use Newton iteration, solve a linear system at each step using Conjugate Residuals



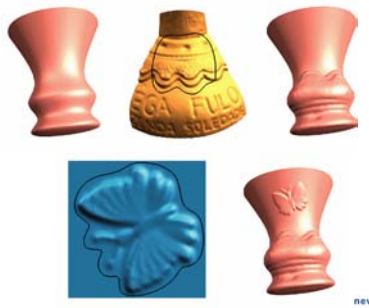


# Resampling

On the common parameterization:

- Resample source details at target vertex positions in parametric domain
- Point location + evaluation (bilinear or subdivision)
- Use differentials to transform details

## Examples

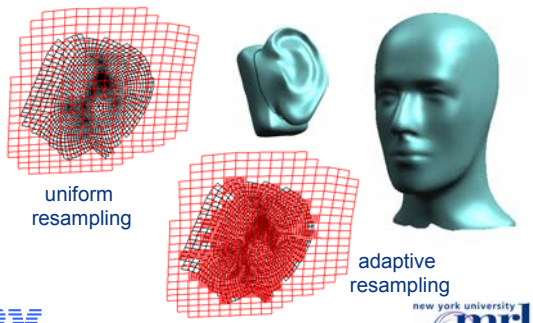


## Interactive Demo

## Examples

target | pasting with target details removed | pasting with target details preserved

## Examples

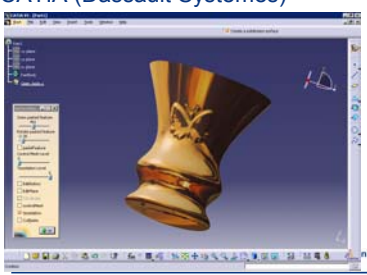


uniform resampling

adaptive resampling

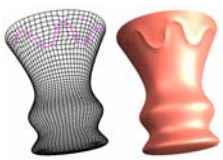
## CATIA Integration

- Prototype cut-and-paste functionality in CATIA (Dassault Systemes)



## Future Work

- Photoshop-like feature blending
- Combine pasting with texture generation
- Sharp features (Biermann, Martin, Zorin, Bernardini, PG2001, GMOD 02)
- Hierarchical pasting



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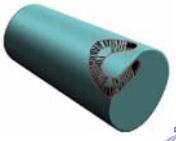
# THE END


# Generalized Radial Parameterization

- Start with a spine: parameterize boundary by (spine point, direction, distance)
- Map spine onto target
- Walk along geodesic rays from spine points



# Blending

Smooth transition between the pasted feature and the target

feature | original alpha map | pasting w/o blending | smoothed alpha map | pasting w blending